PVTRIN
INSTALLER CERTIFICATION

TRAINING OF PHOTOVOLTAIC INSTALLERS

Definition of installers' professional framework and development of the training methodology

Catalogue of common failures and improper practices on PV installations and maintenance

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INTELLIGENT ENERGY EUROPE

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PVTRIN: The PVTRIN project scope is the development of a training and certification scheme for technicians, according common accepted criteria and standards, focused on the installation and maintenance of small scale PV.

The expected results are: Accredited training courses and an operational certification scheme for PV installers in 6 participating countries; Practical training material/tools for installers and their trainers; Web portal with access to technical information on PV installation/integration; 8 pilot training courses implemented, a pool of skilled/certified PV installers; A roadmap for the adoption of the certification scheme across Europe.

Long term, PVTRIN will contribute to the PV/BIPV market growth in the participating countries, provide a supporting instrument for EU MS to meet their obligations for acknowledged certifications for RES installers till 31/12/2012 and enforce the MS efforts to achieve the mandatory target of a 20% share of energy from RES in overall Community energy consumption by 2020. The PVTRIN is co-financed by the Intelligent Energy - Europe (IEE) programme.

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1 Scope of the deliverable

A catalogue with the most common mistakes and improper practices from information gathered from PV industry key actors, engineers and constructors and PV owners' experiences is created in the frame of this deliverable. This catalogue will be periodically updated during the project's lifetime with the involvement of the industrial associations.

The intent of this catalogue is to consolidate the most important mistakes that may appear during the installation of a PV system in order the installers can recognize and avoid them. So the catalogue will prove to be helpful not only for the training courses but mainly as a reference for the installers when needed.

This deliverable was developed with the input of the industry actors and the support of a pool of EPIA's[1] members.

As a general comment, most common failures are not encountered because of bad practices in one specific step, but are a combination or accumulation of suboptimal actions in different stages or simply due to wrong or inadequate communication between the designers and the installers.

To avoid this kind of fault, the PV sector needs a diverse and qualified workforce. A skilled labour calls for an appropriate training and certification scheme.

[1] The European Photovoltaic Industry Association is the world's largest photovoltaic industry association, with members active along the whole solar PV value chain from polysilicon production to pv system design.

2 Introduction – PV as a reliable technology

2.1 A little bit of history

The first terrestrial PV applications only took place since the beginning of the 1970s – mainly stand-alone systems and in small volumes. It is not until the end of the previous century that the scale of the PV market started to become significant and it was only in 2004 that the annual PV installed capacity reached above 1 GW.

As such, PV can be considered a rather 'young' technology compared to conventional sources of power generation. Nevertheless, the photovoltaic effect was discovered in 1839 and ever since extensive research has been performed. The first research was dedicated to create real-world applications (space and later terrestrial), whereas later on the focus lay on improving the quality, reliability and safety of the technology. Still today, the PV industry is investing an extensive part of its revenues into research and development.

2.2 Few failures in old PV installations

Analysis by Fraunhofer ISE and KfW on the faults occurring in systems that were installed under the 1,000 and 100,000 roofs programme in Germany has been summarised by the German Energy Society (DGS). They discovered in the first place that total failures of PV systems are extremely rare. Moreover, it seems that in most cases when there was a failure, it was clearly related to the equipment.

2.3 The quality of equipment has improved rapidly

Nowadays, most of the equipment has known incredible improvements in terms of quality and safety. Also testing requirements are better defined than before and the processes for testing are becoming more and more standardized. The list below (Table 1) provides some examples of areas where problems have occurred. It is also explained how reliability has improved in these areas – either through standardization, guarantees or improvements in the products:

Table 1: Quality problems with PV systems (DGS, 2008)

Problems related to the PV equipment		
PV modules	**DC cables and connectors**	**PV inverter**
IEC standardization (IEC 61215, IEC 61646, IEC 62108 & IEC 61730)	Improved standardization	IEC standardization (IEC 62109)
Guaranteed lifetime by PV module manufacturers (90% after 10 years and 80% after 25 years)	Plug connectors are now widely spread	
	Physical lifetime of cables now is 45 years	
	Cable protection is available on the market	
	Automatic insulation monitoring by inverters	
	Switches (AC or DC)	
Problems related to the planning, design and installation		
No expansion joints: new mounting structures & flexible joints are available		
Incompatible metals		
Wrong dimensioning of the PV inverter/cables : design and simulation tools are now available		

2.4 Conclusion

This clearly shows that, in terms of failures related to PV systems, the focus nowadays has shifted away from the components. Today, it is the planning, design and physical installation of the system, rather than the reliability and performance of the components it selves that need further improvement.

3 PV in all its varieties

During the installation of a PV system, a considerable number of elements need to be taken into account.

3.1 A large variety of sites and applications

First of all, a large variety of sites – read rooftops in the case of small-scale rooftop systems exists: pitched or flat, different orientation, inclination, etc. Moreover, given the attention that certain governments are giving to building-integrated photovoltaics (BIPV), new concepts are being developed. Nowadays, PV can be introduced in the façades of buildings; the products can have the shape of roof tiles, glass walls, windows, etc. It is thus also obvious that the specificities of each site define the planning and design of the PV system. The table below outlines the different types of applications and maps them according to different market segments. Small-scale systems under the scope of article 14 of the RES Directive (2009/28/EC) – and accordingly under the scope of the PVTRIN Project are to be identified as all those rooftop (BAPV) – second row and all integrated systems (BIPV) – third row of table 2. Of course this segmentation is only indicative and is based on which applications and system sizes can be currently found into the market.

Table 2: Segmentation of the current PV market into different application types and market segments (EPIA, 2010)

Market segment Type of applications	Residential	Commercial	Industrial	Utility-Scale
	< 10 kWp	**10kWp - 100kWp**	**100kWp - 1MWp**	**>1MWp**
Ground-Mounted			□	□
Roof-top (BAPV)	□	□	□	
Integrated into Façade/ Roof (BIPV)	□	□		

3.2 *A large variety of components*

Secondly, there are also a large number of components in order to build a PV system. The key parts of a solar energy generation system are:

- Photovoltaic modules to collect sunlight
- An inverter to transform direct current (DC) to alternate current (AC)
- A set of batteries for stand-alone PV systems
- Support structures to orient the PV modules toward the Sun.

The system components, excluding the PV modules, are referred to as the balance of system (BOS) components.

PV modules of different technologies can be found on the market. They are classified as first, second or third generation. First generation technology is the basic crystalline silicon (c-Si). Second generation includes Thin Film technologies, while third generation includes concentrator photovoltaics, organics, and other technologies that have not yet been commercialized at large scale. Table 2 summarises the different PV technologies and their efficiency range (status of February 2011). Every PV technology has its specific advantages and can therefore be used in one application or another. Moreover, because the design of the PV system is highly influenced by the choice of the PV technology, the selection process regarding the PV technology and the type of PV modules is critical and requires sufficient knowledge about PV technologies.

Table 3: Overview of commercial PV technologies (EPIA, 2010)

Commercial Module Efficiency							
Technology	**Thin Film**					**Crystalline Silicon**	
	(a-Si)	(CdTe)	CI(G)S	a-Si/ µc-Si	Dye s. cells	Mono	Multi
Cell efficiency Module efficiency	4-8%	10-11%	7-11%	7-9%	2-4% (LAB)	13-19%	11-15%
Area needed/kW (for modules)	~15m^2	~9 m^2	~10 m^2	~12 m^2		~7 m^2	~8 m^2

For grid-connected systems, the **inverter** is the device that transforms the DC power output at module level into AC power for injection in the electricity network. As such, it is a crucial element for grid-connected PV systems, regardless of the size of the PV system. The PV inverter ensures the electrical connection and again there are multiple solutions available on the market, not only in terms of the size

of the inverter, but also the way it can be applied: central, multi-string or even at module level – either integrated into the module or not. In addition, more and more additional tools, such as power optimisers, switches, etc. are being integrated into PV systems in order to enhance the performance and safety of PV systems under certain conditions. It can be clearly seen that in order to take all these elements into account and be able to reply to changing customer demands influenced by political decisions and public opinion, an installer/designer of PV systems should be well educated about which products are available on the market.

The same accounts for **mounting** the modules and **connecting** them. Numerous companies are engaged in the design of mounting structures, cables and interconnectors. Innovative solutions are being developed at rapid pace. Installers have to be aware of the specificities of the latest products in order to be able to reply to customer needs. Training is therefore crucial.

3.3 *A large variety of national requirements*

Thirdly, there are different national requirements and many actors that have to be taken into account. Installers do not only have to be able to physically install a perfectly working PV system, but they have to be able to deal with customers during the sales process (by for example advising them on the different support mechanisms that are in place), with **administrative** authorities during the permission process and with network operators and other grid-related actors for the **connection** of the PV system. Installers should be capable of assisting the end-customer in the entire process until the installation is finalised and well connected to the grid and beyond (maintenance).

This is in line with ***Annex IV of the RES Directive*** which argues demands installers to receive education about *"the market situation of solar products and cost and profitability comparisons, ecological aspects, components, characteristics and dimensioning of solar systems, selection of accurate systems and dimensioning of components, determination of heat demand, fire protection, related subsidies, design, installation and maintenance of solar photovoltaic systems"*.

The PV industry therefore believes that *"considering the diversity of building and PV requirements in the different EU Member States, it will be very difficult to create one harmonized certification scheme for the EU. However, the principle of mutual recognition of the different national certification schemes calls for them having a common ground. Therefore, some minimal requirements are to be drafted and a specialized body needs to ensure that all national schemes fulfill these" (Official EPIA position - 2010).*

As such, industry supports the idea of creating a **common ground – minimal requirements – for all Member States.** The implementation of the training schemes will then be determined and adapted at national level. At the moment, building, administrative procedures and grid connection requirements are different in most EU member states. As such, it will be difficult to develop training courses that tackle all issues in all member states, without adaptations to the national legislation and normative framework.

Another clue lies in the **streamlining of administrative and grid connection procedures**. For an overview on the existing administrative barriers in EU member states, please refer to the PV LEGAL project (www.pvlegal.eu). The European Photovoltaic Industry Association has developed recommendations regarding sustainable market growth in which advises are provided regarding the streamlining of administrative and grid connection procedures. Please refer to the Photovoltaic Observatory – Policy Recommendations (www.epia.org/publications).

4 Common failures and improper practices

Given the huge varieties and modularity of PV systems, it is obvious that a significant number of mistakes can be made in case of insufficient training of installers about the availability and technical parameters of the different PV components as well as about the national requirements when it comes to administrative processes, grid connection requirements and building regulations.

There are a number of stages in the development of a PV system in which mistakes can occur:

- Site selection
- Design and planning of the system
  - Selection of components
  - Mechanical failures
  - Electrical failures
- Physical installation of the components
  - Mechanical failures
  - Electrical failures
- Safety (personnel safety as well as safety of installation from e.g. external exposures)
- Service, including inspection & maintenance (insufficient)

For example, many installation faults of different severity were found in the 200 systems from the "1000-Roofs-Programme", which were inspected. Table 4 gives an overview on the type of defect and the relative occurrence.

Table 4: Type and frequency of installation defect (IEA –PVPS Task 7, 2002)

Installation faults	Fraction of systems affected
Solar generator cabling not mechanically fastened	**24 %**
Lack of heat dissipation of string diodes	**60 %**
Loose terminal connections	**5 %**
Unsealed cable entry from top of junction box	**-**
Broken printed circuit boards (PCB) in junction box	**-**

Loose or broken connections can be caused by poor workmanship during installation and in a few cases broken printed circuit boards (PCB) in junction boxes were reported, which caused arcing across the fissures.

Possibly, the cracks were caused by too much torque or pressure due to a poor system design. Depending mainly on the operating voltage, these faults can lead to an electric arc and subsequently to destruction of the module junction box.

Most common failures are not encountered because of bad practices in one specific step, but are a combination or accumulation of suboptimal actions in different stages or simply due to wrong or inadequate communication between the designers and the installers.

To avoid this kind of fault, the sector needs a diverse and qualified workforce. A skilled labour calls for an appropriate education and certification scheme.

4.1 Site selection

Site selection includes obvious aspects such as orientation, inclination and shading (including solar resource prediction), but also elements which are less straightforward, such as environmental impact assessments when it comes to large ground-mounted installations.

Common failures in the field of initial site selection for **rooftop systems** are very rare. Most installers (as well as end-customers) are aware of the importance of orientation and inclination of the PV installation. We will see almost no north-facing installations on residential roofs.

Unfortunately, **shading** is not always taken into account and more easily overlooked by the designer/installer. Therefore, it is important to perform detailed solar resource predictions, taking into account the orientation, inclination and all potential shading by surrounding trees and/or buildings.

Regarding larger **ground-mounted systems**, an important aspect is to analyse the potential impact of such a large PV plant on biodiversity. Therefore, it is important to perform an **environmental impact assessment** and the results of such assessment need to be openly discussed with the public, policy-makers and all other involved players. Although the decision to go through with such projects should be looked at on a case by case basis, the German Renewable Energies Agency has issued a report “Solar Parks – Opportunities for biodiversity”.

4.2 Design and planning of the system

The design and planning stages include all decisions taken on the appropriate size of the system as well as the selection of the different components. It is important to take into account basic structural load and wind load calculations. Moreover, emphasis should be put on the sizing, including the size and selection of an appropriate inverter, cables, power optimiser and switch devices as well as combiner boxes and transformers. This task normally ends with a modelling exercise on the future performance of the PV system and therefore also includes knowledge about software and simulation tools for yield modelling.

For residential systems, it is of critical importance to **respect the building and safety codes**, including measures on ventilation of the building, access for fire departments, maximum load, etc. When the roof is not appropriate for the installation of a PV system, this should be simply acknowledged.

Moreover, the **choice of components** is critical; especially when it comes to PV systems in sub-optimal locations, such as west-facing roofs or flat roofs where mounting the modules is not an option because of load limitations. Taking into account the latest innovations is critical, e.g. specialised products targeted for east-west facing roofs, light-weight flexible PV modules, etc.

It has to be acknowledged that without sufficient training, the likelihood of mistakes during this step can be significant.

Common mistakes to be encountered in this stage are then:

- Incorrect energy yield prediction
- Different azimuths or inclinations in the same string
- Strings with modules of different power rating
- Stability: insufficient structural load calculations
- Sizing: e.g. undersized cables
- Shading problems not sufficiently taken into account
- Mismatch: e.g. inverter mismatch or generation meter not well fitted to inverter output
- Incorrect circuit protection
- No lightning protection, earthing and surge protection
- Building codes and electrical codes for grid connection not taken into account
- Missing documentation at late stages of design (not compliant with IEC standard)

Moreover, it is clear that any **last minute changes in one of the design stages** affects the entire configuration of the PV system design and can have a detrimental impact on the performance or safety of the final installation.

4.3 Physical installation of the components

This step requires normally the combined work of a roofer and an electrician. Again, it is clear that without sufficient training on the specificities of PV, the likelihood of mistakes during this step can be significant.

Common mistakes to be encountered in this stage are then:

- Installer does not follow the design of the system
- Insufficient inverter & module ventilation (the area around the inverter should be kept clear to allow good air flow for proper cooling
- Roof perforation without adequate sealing methods
- Poor wiring: tight or loose cables
- Labelling not present or incorrect
- No earthing or lightning protection
- No intervention in the case of rust
- Badly placed sensors

4.4 Safety

Safety issues include both the personnel level (worker safety) as well as the product level (safety of installation).

Worker safety:
Ideally, a team responsible for the installation of a PV system should consist of an **electrician and a roofer**. The electrician should manage the electrical DC connections as well as the connection to the grid, whereas the roofer should have sufficient experience to manage the installation of the panels mechanically on the roof and make the interconnections between the modules on the DC side. Ideally; electricians, roofers and other construction workers are to bring their knowledge together in a new kind of job description which could be called "solar installer".

Safety of installation:
An important element that is also being discussed extensively in certain EU countries is **fire protection**. First of all, it is crucial to understand that in case of a fire where a PV system was present, the fires were mainly caused by external fire sources and only few cases have been reported in which the PV system itself was the source of fire (improper polarity can cause severe damage to the array and system electronics and has been known to cause fires in some systems). The concerns are therefore not related to the quality of the PV systems itself, but to the safety of fire fighters when extinguishing a fire in a building with a PV system. Therefore, 4 elements are of crucial importance: the design of the PV system, the quality of the PV components, the quality of the installation and communication towards other stakeholders (such as fire departments). It should also be pointed out that multiple solutions are available in all stages of design and installation, such as selecting and designing the site in order not to block the access for fire departments, foresee sufficient labeling and applying it correctly, designing the electrical plan (for cables and other electrical equipment) in accordance with safety requirements, etc…

A recent **project *"PV Fire Prevention and Firefighting Measures"*** lead by BSW (the German Solar Industry Association) has lead to the publication of a set of technical guidelines for installers. It states that *"Intact PV systems do not pose a risk. In the event of a fire, personal safety can be maintained by the following the basic principles for electrical installations, as they are laid out in MLAR guidelines and in the respective State Building Regulations".* This protection target can be achieved through the following:

- Organizational measures, such as
  - labeling the PV system at the building's connection box and main distributor in the form of an indicator sign
  - general plans for emergency workers
  - supplements to fire response plans
- Structural measures, such as
  - fire-resistant routing of DC power cable or
  - routing of DC power cables outside of the building or
  - installing the inverter outside of the building or at the building entry point, so that only AC wiring needs to be laid inside the building
- Technical measures such as
  - DC disconnect switch, with remote control for the fire department in the area of the building's main fuse box, to shut down the main DC main line or the module strands.

Image 1: Owners should stay away from the PV system during and after a fire and inform the fire brigade about the particular hazards from the PV system.

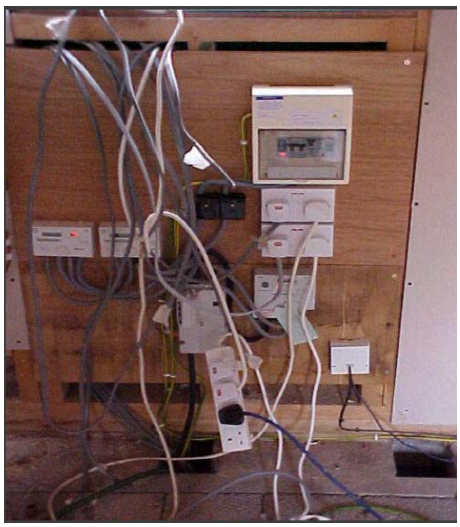

Image 2: Improper wiring method

Image 3: Short circuit and overvoltage converter

Image 4: Crack damage – fixing system

Image 5: Storm damaged modules

4.5 Service, including inspection and maintenance

An installer is of course not only a technician but also a salesperson. Basic marketing skills are therefore a must. Good knowledge about the environmental, financial and other economic benefits of PV is indispensible.

Common mistakes to in this area are:

- Manuals, warranties, test certificates, grid connection docs not supplied to owner/operator
- Not being able to deliver information on the latest innovations and specialised applications (BIPV)
- Not being able to deliver information on administrative requirements, grid connection procedures, support schemes and other related benefits
- Too aggressive sales attitude
- Failure to deliver quick and adequate inspection and maintenance services

PV system maintenance includes maintaining all parts of the system and requires little maintenance, except for batteries in case of autonomous systems. Batteries maintenance depends on the type and the charge/discharge cycles. Maintenance should be performed at least once a year, but the installer should additionally inform the system owner to monitor the system performance. The most common maintenance issue is the cleaning of the glass area to remove dirt and dust which can be done by washing the module with water. Cleaning is necessary during long dry periods when rain cannot provide natural cleaning. The modules should be cleaned when they are not excessively hot.

5 List of common failures and improper practices

PARAMETER	FAILURE / IMPROPER PRACTICE
1. Site selection	
Orientation	- north / west facing installations
Inclination	- different azimuths or inclinations in the same string - array not tilted at an angle of latitude (for throughout the year best performance)
Shading	- place the system in area surrounded by trees and/or buildings - seasonal shading is not taken into account
Corrosion	- modules are located in areas exposed to salt water
Biodiversity (for large ground-mounted systems)	- potential impact to wildlife is neglected because of inadequate EIA
2. Design and planning of the system	
Structural load	- age and condition of the roof is not considered - not use of specified hardware leading to stability problems - no respect to the building codes
Wind load	- inadequate mounting - system not mounted on concrete bases
Location	- no respect to the building and safety codes (eg overload the roof, no access for fire departments) - BOS are not sited in weather resistant or rain-tight enclosures
Equipment	- inappropriate inverter, undersized cables, power optimiser and switch devices as well as combiner boxes and transformers
Lightning/grounding	- no lightning protection, earthing and surge protection - PV system installed in an exposed location - allow copper (equipment grounding conductor) to come in contact with the aluminum rails and module frames
Electrical connections	- improper polarity - incorrect circuit protection - mismatch: e.g. inverter mismatch or generation meter not well fitted to inverter output - lengths of electrical wiring are not minimized - electrical codes for grid connection not taken into account

PARAMETER	FAILURE / IMPROPER PRACTICE
3. Physical installation of the components	
Shading	- distances between the module rows are not kept
Roof Damage	- perforation without adequate sealing methods
Corrosion	- materials used outdoors are not sunlight/UV resistant
Array Modules and Configurations	- modules are subjected to excessive forces due to thermal expansion of the support structure - put too few modules in series for proper operation of the inverter during high summer array temperatures - insufficient module ventilation - modules of different configurations and different nominal power ratings are used in the same PV array
Inverter	- placed in a position where it is directly exposed to the sunlight - insufficient ventilation - placed in a long distance from the PV array combiner/junction box - installed on or near a combustible surface
Wiring	- tight or loose cables - improper cable support with exposure to physical damage - multiple cables entering a single conductor cable gland
Conductors	- not supported within 30cm of boxes or fittings - bending conductors too close to connectors
Batteries	- not installed in an enclosure separated from controls or other PV system components - installed close to radioactive and flammable materials - exposed to direct sunlight - exposed to high temperature
Labelling and warning signs	- not present or incorrect placed
Sensors	- badly placed
Boxes or conduit bodies	- cover them making nearly inaccessible for service

PARAMETER	FAILURE / IMPROPER PRACTICE
4. Safety	
Technician's safety	- fall protection equipment is not used even though it is needed - noncompliance with accident prevention regulations - work in adverse conditions: wet conditions, strong winds or frosted roof surfaces - the installer walks on the panels - the inverter is installed after wiring
For the event of a fire	
Organizational measures	- not labeling the PV system at the building's connection box and main distributor with an indicator sign - lack of general plans for emergency workers
Structural measures	- no fire-resistant routing of DC power
	- no routing of DC power cables outside of the building or
	- the inverter is installed inside the building
Technical measures	- lack of DC disconnect switch in the area of the building's main fuse box
Maintenance/ Inspection	
Technician	- not annually maintenance of mechanical and electrical connections (circuit currents and voltages, battery electrolyte etc) - front surface of the PV modules not covered during maintenance - bent, corroded, or otherwise damaged mounting components re not replaced - loose components or fasteners are not re-secured or tightened - fire extinguishers are not located in close proximity to the battery - owner is not informed /taught to frequently monitor the system's performance
Owner *(PV installer shall advice the owners for several maintenance measures to be followed)*	- kWh produced is not periodically recorded (deviation from expected values may reason for checking the system) - panels are not adequately washed, when needed - panels are scratched during the cleaning procedure (brushes, and harsh detergents are used) - trees near the system are not adequately trimmed - batteries' surfaces are not kept cleaned - the electrolyte level in the batteries is not checked

6 References

European Projects

- PV LEGAL: http://www.pvlegal.eu
- Qualicert Project http://www.qualicert-project.eu/

Websites

- Ecole Polytechnique Fédérale de Lausanne Institute of Chemical Sciences & Engineering, http://photochemistry.epfl.ch/EDEY/PV_history.pdf
- PVresources: www.pvresources.com
- KYOCERA solar modules assembly and maintenance instructions April 2011 http://www.kyocerasolar.de/index/products/download/English.-cps-34501-files-80034-File.cpsdownload.tmp/Manual_Eng_KD_all_110426.pdf

Books and other publications

- Solar Generation VI (EPIA and Greenpeace, 2011): http://www.epia.org/publications/
- Photovoltaic Observatory – Policy Recommendations (EPIA, 2011): http://www.epia.org/publications/
- Field Inspection Guideline for PV systems, Interstate Renewable Energy Council, 2010 available at www.irecusa.org
- Solar Parks – Opportunities for biodiversity (German Renewable Energies Agency, 2011): http://www.unendlich-viel-energie.de/uploads/media/45_RenewsSpezial_Biodiv-in-Solarparks_ENGL.pdf
- Canadian solar, Solar module installation manual, www.canadian-solar.com
- Solar Frontier K.K. Installation and Maintenance Manual, http://www.solar-frontier.com/
- DGS LV Berlin BRB, German Energy Society (Deutsche Gesellshaft fur Sonnenenergie, Planning and Installing Photovoltaic Systems A guide for installers, architects and engineers second edition, Earthscan, UK, 2008.
- NABCEP, North American Board of Certified Energy Practitioners, NABCEP study guide for photovoltaic system installers, USA 2009.
- Dunlop J. P., Batteries and Charge Control in Stand-Alone Photovoltaic Systems Fundamentals and Application. Sandia National Laboratories USA, 1997
- Reliability Study of Grid Connected PV Systems, Field Experience and Recommended Design Practice (IEA-PVPS Task 7)

Others sources:

- PV Magazine (October 2011 – page 84-87), http://www.pv-magazine.com/
- BRE, http://www.bre.co.uk
- 3E, http://www.3e.eu
- Bundesverband Solarwirtschaft, www.bsw-solar.de
- UNIQA, www.uniqagroup.com
- VdJ and BRJ insurance
- European Commission, http://ec.europa.eu